

## Remarks

Claims 1-6 are pending, claims 7-12 having been withdrawn in response to a Restriction Requirement. Reexamination and reconsideration are requested in light of the amendments to the claims and the discussion which follows.

For ease of reference, the subheadings appearing below match those that appeared in the Office Action.

### Election/Restrictions

Applicant affirms the election of Group I, claims 1-6.

### Claim Rejections – 35 U.S.C. § 102

Claims 1 and 5 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Fujinaka et al. (U.S. 4,806,334).

At the outset, a brief recapitulation of the invention as now claimed will be helpful in distinguishing it from the cited art.

The glass matrix composition of the present invention consists essentially of:  
 $57 < \text{SiO}_2 < 75$ ;  
 $5 < \text{BaO} < 25$ ; and  
 $2 < \text{MgO} < 18$ .

The composition has the characteristics of being chemically resistant to oxidizing and reducing conditions that are encountered in sealing solid oxide fuel cells, and the matrix composition remaining in a glassy state after sealing at temperatures up to 1300°C.

The Examiner correctly notes on page 3 of the Office Action that the '334 reference requires  $\text{Al}_2\text{O}_3$  is required ('334 patent, 4:54-57). That reference also requires  $\text{CaO}$  ('334 patent, 5:66-6:3). The presence of these mandated ingredients cannot be ignored. It would be apparent to one of ordinary skill in the art of glass making that the presence of  $\text{CaO}$  tears out the bridging  $\text{SiO}_2$  bonds, thereby substantially changing the properties of the matrix glass (*e.g.*, lowering in viscosity and raising chemical susceptibility). In contrast, a high viscosity is desired for a sealing glass composition. Further, the interdiffusion of  $\text{CaO}$  with an electrolyte will cause a reduction in the ion transport of the solid electrolyte, limiting severely the power of the cell. It is well-known that small percentages of  $\text{CaO}$  in stabilized  $\text{ZrO}_2$  result in a two-three order drop in ion conductivity. Thus, an objective of the claimed composition (high power) would be compromised by the presence of  $\text{CaO}$ . Accordingly, it cannot be said that the '334 patent anticipates the invention as defined in claim 1, which excludes ingredients other than those recited that would materially change the properties of the resulting glass matrix composition.

Claim 5 incorporates the limitations of claim 1, and thus rises or falls therewith. Claim 5 recognizes that what works with  $\text{BaO}$  works also with  $\text{SrO}$ . Thus, claim 5 groups the combined amounts of  $\text{BaO}$  and  $\text{SrO}$  such that their compositions lie between 5 and 25 mol percent of the glass matrix composition. Claim 5 therefore cannot be said to be anticipated by the '334 patent for the same reasons as advanced above.

On page 4 of the Office Action, claims 1 and 5 were rejected under 35 U.S.C. § 102(b) as being anticipated by Gardner (U.S. 3,935,017).

This reference discloses a glass composition that is used as a minor (5-10 % weight basis) sintering aid for sintering aluminum oxide powders into dense solids. In contrast, in the present invention, the glass (and the forsterite) are both present as major phases, *i.e.*, the glass is not a minor additive of the sealing glass composition.

In contrast to a sealing glass, a sintering aid typically has low viscosity. In the claimed invention, the glass matrix composition has the characteristic of having a high

viscosity, which contributes to its sealing properties. In the '017 patent, the applicable use temperature is between 1500°C - 1600°C ('017 patent, 8:37; 8:49). In contrast, the invention as claimed calls for the matrix composition to remain in a glassy state after sealing at temperatures up to 1300°C. At the high temperatures disclosed in the '017 patent, the fine pore structures of the electrodes in a solid oxide fuel cell would be ruined.

Claim 5 incorporates the limitations of claim 1 and rises or falls therewith. For these reasons, neither claims 1 nor 5 can be said to be anticipated by the '017 patent.

*Claim Rejections – 35 U.S.C. § 103*

Claims 1 and 5 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Budd (WO 98/46540).



The claimed invention calls for a glass matrix composition that "remains in a glassy state after sealing at temperatures up to 1300°C." In contrast, the '540 reference discloses glasses that do not remain soft at high temperatures. Instead, they become devitrified (*i.e.*, they no longer remain in a glassy state so they can be reworked). For example, the '540 reference requires that the melt "is cooled rapidly to a temperature below 900°C . . . to form a precursor glass . . ." Consider, for example, glass number 7 in the '540 reference. Its composition is set forth in Table 1. Table 2 indicates that its coefficient to thermal expansion (CTE) is 9.3, which results from the slowest cooling rate (impractical for the subject invention) of 2°C per minute. Such a CTE would be unacceptable for a sealing glass composition.

The '540 reference has a large amount of particulate BaO-rich phase: 2 MgO·BaO·2SiO<sub>2</sub> (p. 5, lines 3-4). In contrast, the present invention derives its large CTE from (the more economical and lower density) forsterite.

Claim 5 incorporates the limitations of claim 1 and rises or falls therewith. It is not rendered obvious by the '540 reference for the same reasons asserted in connection with claim 1.

On page 5 of the Office Action, claims 1 and 3-6 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Durschang (EP 1008563) in view of Bagger et al. (EP 1010675).

Applicant respectfully notes that reliance on the Abstract alone may obscure other relevant details that are contained in portions of the reference which lie beyond the Abstract. These comments are thus based primarily on the Abstract itself.

In the summary table spanning across pages 5-6 of the '563 reference, all of the compositions tested had 4-6% alumina and 2-5% of calcia. Similarly to the above discussion of the Budd reference, these additives help form a devitrified glass ceramic which cannot be reworked. Thus, these added components materially affect the novel basic characteristics of the present invention, and thus be outside the invention as claimed.

The '563 reference discloses the silica concentration values that range from 38-47% – none of which is close to the lower limit of 57% of the invention as now claimed. Thus, it cannot be said that the '563 reference discloses a glass composition having overlapping ranges of components with the glass matrix composition described by claim 1 (amended). For clarity, the lower limit of SiO<sub>2</sub> has been raised to 57 mol percent and the word “about” no longer appears in any of the pending claims.

Claim 3 calls for a glass matrix-ceramic particulate composite consisting essentially of a glassy phase (with the cited ingredients and between x<sub>1</sub> and y<sub>1</sub> of a forsterite phase consisting of Mg<sub>2</sub>SiO<sub>4</sub>). Only the forsterite filler is in phase equilibrium with the low BaO, low MgO glass (which lies across a wide phase separation range from the forsterite). Noteworthy also is that the addition of forsterite to the composition disclosed in the '563 reference may not function for the intended purpose of the claimed invention. For example, the addition of forsterite to the preferred compositions of the '563 reference would lead to an unacceptably high CTE for a seal material.

Under § 103, the teachings of the references can be combined only if there is some suggestion or incentive to do so (citations omitted). In light of previous discussion, Applicant respectfully suggests that the obviousness rejection has failed to articulate a rationale by which a person of ordinary skill in the art of making sealing glasses would have been motivated to combine the references to arrive at the claimed invention. MPEP § 2143.01.

The suggestion to combine should not come from the applicant himself. If the rejection is borne of hindsight, such a rejection would be improper. Further, as combined, the references would fail to teach the claimed invention for the reasons articulated above.

Claim 4 depends from claim 3 and incorporates its limitations. It rises or falls therewith. Claim 5 incorporates the limitations of claim 1 and thus rises or falls therewith. Claim 6 rises or falls with claim 3. For all of the above reasons, it cannot be said that the invention defined by claims 1 and 3-6 are unpatentable over the proposed combination of references.

On page 6 of the Office Action, claims 1, 2 and 5 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Dumbaugh et al. (U.S. 3,501,322).

The Examiner observes that the reference “applies the presence of  $\text{La}_2\text{O}_3$  and  $\text{Al}_2\text{O}_3$ , whereas the present claims employ “consisting essentially of” claim language. The application disclosed in the ‘322 reference is not a sealing glass composition for SOFC’s. Instead, it is a glaze for high alumina substrates for microcircuits. The expansion coefficients listed in Table III are far too low for use in SOFC’s. Because of the expansion difference, glazes for alumina will not have an acceptably high CTE that will work for sealing stabilized zirconia. As noted above, the addition of alumina acts as a network modifier and (undesirably) lower the viscosity of the glass.

The rationale for setting the  $\text{Al}_2\text{O}_3$  minimum is explained on the basis of chemical durability (in moist near-room temperature environments) (col. 3, lines 44-46). The  $\text{La}_2\text{O}_3$  minimum is explained in col. 3, lines 48-51 on the basis of expansion.

For these reasons, it cannot be said that the invention as claimed in claim 1 is rendered obvious by the '322 reference. Claim 2 rises or falls with claim 1, as does claim 5. For these reasons, it cannot be said that the invention as defined in claims 1, 2 and 5 is rendered obvious by the '322 reference.

### CONCLUSION

Applicant has made a bona fide attempt to respond to each rejection made. All formal and substantive requirements of patentability are now believed to have been met. Accordingly, a Notice of Allowability is solicited.

Respectfully submitted,

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Date: December 18, 2002

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*Attachment*

**VERSION WITH MARKINGS TO SHOW CHANGES MADE**

*Please amend claims 1-6 as shown below:*

1. (Amended) A [first] glass matrix composition consisting essentially by mol percent of [about]:

[55] 57 < SiO<sub>2</sub> < 75;

5 < BaO < [30] 25; and

2 < MgO < [22] 18, said composition having the characteristics of being chemically resistant to oxidizing and reducing conditions encountered in sealing solid oxide fuel cells and the matrix composition remaining in a glassy state after sealing at temperatures up to 1300°C.

2. (Amended) The [first] glass matrix composition of claim 1, consisting essentially by mol percent of [about]:

[60] 67 < SiO<sub>2</sub> < 75;

[15] 10 < BaO < [30] 20; and

7.5 < MgO < 12.5[, to form a second glass matrix composition].

3. (Amended) A [third] glass matrix-ceramic particulate composite consisting essentially of [by mol percent of about]:

a glassy phase consisting of (by mol percent)

[55] 57 < SiO<sub>2</sub> < [65] 75;

5 < BaO < [15] 25;

[25] 2 < MgO < [35] 18, said composition having the characteristics of being chemically resistant to oxidizing and reducing conditions encountered in sealing solid oxide fuel cells and the matrix composition remaining in a glassy state after sealing at temperatures up to 1300°C; and

between 15 and 40% by weight (between 5 and 30 mol percent) of a forsterite phase consisting of Mg<sub>2</sub>SiO<sub>4</sub>.

4. (Amended) The glass matrix-ceramic particulate composite of claim 3, consisting essentially of [by mol percent of about]:

a glassy phase consisting of (by mol percent)

[57] 67 < SiO<sub>2</sub> < [63] 75;

[7] 10 < BaO < [13] 20;

[27] 7.5 < MgO < [33] 12.5; and

between 20 and 35 percent by weight (between 10 and 25 mol percent) of a forsterite phase consisting of Mg<sub>2</sub>SiO<sub>4</sub>.

5. (Amended) The glass matrix composition of claim 1, consisting essentially by mol percent of [about]:

[55] 57 < SiO<sub>2</sub> < 75;

5 < (BaO + SrO) < [30] 25; and

2 < MgO < [22]18, said composition having the characteristics of being chemically resistant to oxidizing and reducing conditions encountered in sealing solid oxide fuel cells and the matrix composition remaining in a glassy state after sealing at temperatures up to 1300°C.

6. (Amended) The glass matrix-ceramic particulate composite of claim 3, consisting essentially of [by mol percent of about]:

a glassy phase consisting of (by mol percent)

[55] 57 < SiO<sub>2</sub> < [65] 75;

5 < (BaO + SrO) < [15] 25; and

2 [25] < MgO < [35] 18, said composition having the characteristics of being chemically resistant to oxidizing and reducing conditions encountered in sealing solid oxide fuel cells and the matrix composition remaining in a glassy state after sealing at temperatures up to 1300°C; and

between 15 and 45 percent by weight (between 5 and 30 mol percent) of a forsterite phase consisting of Mg<sub>2</sub>SiO<sub>4</sub>.